

# ALUMINUM

## Project Fact Sheet



## LOW-TEMPERATURE REDUCTION OF ALUMINA

### BENEFITS

- Annual energy savings of about 99 trillion Btu by 2025
- Energy cost savings of \$580 million per year for the U.S. aluminum industry
- CO<sub>2</sub> reduction of 4.5 million tons per year

### APPLICATIONS

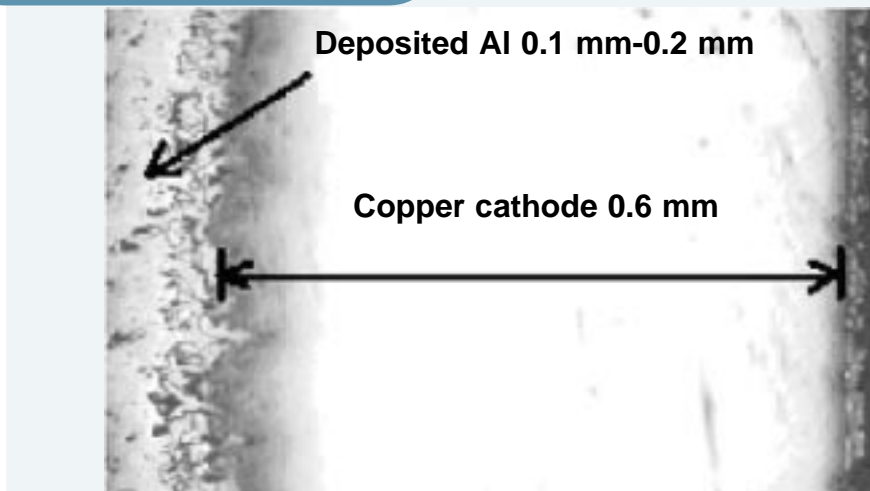
The development of a low-temperature process for the production of primary aluminum is one of the major challenges that the aluminum industry faces today. Successful results of this research will strengthen the position of the domestic aluminum companies in an increasingly competitive global aluminum marketplace.

## LOW-TEMPERATURE REDUCTION OF ALUMINA USING FLUORINE CONTAINING IONIC LIQUIDS

Primary aluminum produced by the Hall-Héroult process is one of the most energy intensive (~15 kWh/kgAl) materials available. The production of primary aluminum also contributes significantly to carbon dioxide emissions due to the process reaction and the generation of electricity. The high-energy consumption of this process is mostly due to the high temperature (960° C) necessary for electrolysis. No suitable substitute has been found for cryolite as a molten salt for the electrolytic reduction of aluminum, despite its high melting point. Cryolite's ability to dissolve alumina and its strong electrical conductivity has made it an inseparable part of the production of aluminum for the past 100 years. However, recently developed ionic liquids provide a new promising possibility for aluminum production. Ionic liquids are salts that are fluid at room temperature. Some studies have demonstrated the feasibility of using chloride ionic liquids to reduce aluminum chlorides and fluoride-based ionic liquids can potentially be used to dissolve and reduce alumina at room temperature.

Research partners will investigate the potential for using ionic liquids as the electrolytes for the production of primary aluminum. The research will focus on identifying a suitable ionic liquid that can be used for industrial electrodeposition of aluminum at temperatures significantly lower than those encountered in the Hall-Héroult process. The effect and optimization of the main electrolytic parameters will be studied, and the results will be compared with current technology. The fundamental insight obtained from this research will provide a science-based foundation for developing a process to produce aluminum at low temperatures, thus increasing energy savings and lowering costs.

### REDUCTION OF ALUMINA



Electrodeposited aluminum on a Cu substrate obtained using chloride-based ionic liquids as electrolytes.



## Project Description

**Goal:** The goal of this project is to develop a low-temperature reduction process for the production of primary aluminum using ionic liquids containing fluorine.

The significant hurdles to overcome include:

- the ability to synthesize ionic liquids containing fluorine, which are studied less than chloride-based ionic liquids;
- the ability to enhance the electrical conductivity of the ionic liquids using appropriate additives; and
- the ability to solubilize  $\text{Al}_2\text{O}_3$  in ionic liquids.

## Progress and Milestones

The goal of this research will be accomplished by conducting a set of tasks that will provide insights into using ionic liquids as electrolytes for the production of primary aluminum. The research involves the following efforts:

- Perform the necessary reactions to produce ionic liquids containing fluorine;
- Characterize the ionic liquids by measuring their key properties, such as conductivity, viscosity, and stability;
- Determine the solubility of alumina in different ionic liquids at different temperatures by chemical analysis and EMF techniques;
- Perform alumina reduction in ionic liquids and determine the effects of the electrolytic processing variables;
- Use a variety of characterization techniques to study the composition and morphology of the deposits;
- Obtain correlation between the electrolytic variables and the aluminum deposit and determine the best conditions of operation; and
- Provide recommendations for scaling to pilot plant tests.

## Commercialization Plan

Commercial adoption of the fundamental knowledge gained from this research will take place through the active participation of industry partners. The knowledge developed during the project will be transferred to the participating companies throughout the course of the project. The companies participating in the project have a clear and direct interest in implementing the technologies developed in the program.



### PROJECT PARTNERS

The University of Alabama  
Tuscaloosa, AL

Albany Research Center  
Albany, OR

Century Aluminum Company  
Hawesville, KY

Secat, Inc.  
Lexington, KY

University of Kentucky  
Lexington, KY

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